

LARGE RAPIDITY GAP SURVIVAL PROBABILITIES

G. Pancheri

INFN Frascati National Laboratories



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WHAT IS NEEDED TO CALCULATE THE SURVIVAL PROBABILITY FOR LARGE RAPIDITY GAPS

vector boson vector boson to Higgs or other VV state



$P_{\text{no-inel}}$ = probability of **no inelastic** interactions

- Only very **low-pt** particle emission can take place



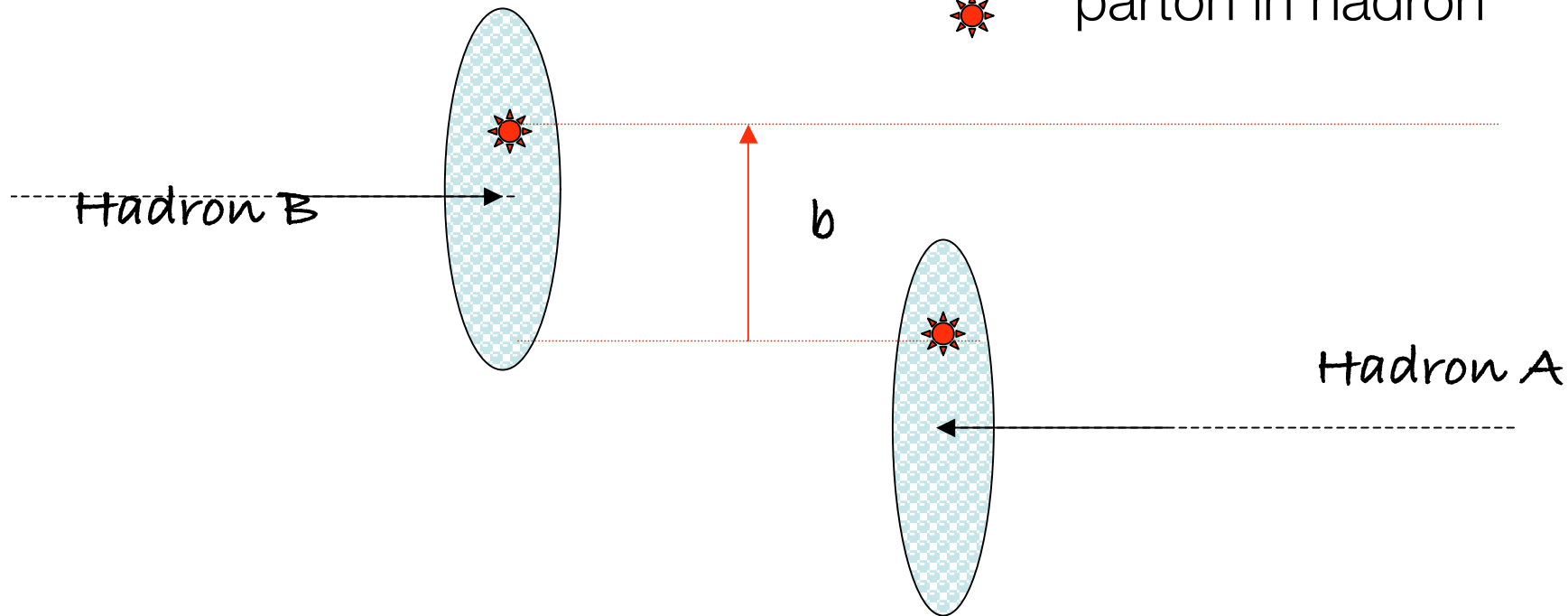
$A(b,s)$ = probability to find partons which will **not** undergo **hard** collisions

CALCULATE $\mathcal{P}_{\text{NO-INEL}}$

- $\mathcal{P}_{\text{no-inel}} = \mathcal{P}_{\text{no-inel}}(b, s)$

\sqrt{s} = c.m. Energy hadrons AB

☀ parton in hadron



$$\mathcal{P}_{\text{NO-INEL}}(B, S)$$

- Poisson distributed (independent) collisions

$$\Pi\{k, \bar{n}\} = \frac{\bar{n}^k e^{-\bar{n}}}{k!}$$

- Now sum on all possible distributions

$$\sum_k \Pi\{k, \bar{n}\} = 1 - e^{-\bar{n}}$$

In Eikonal representation



$$\bullet \sigma_{inel} = \int d^2\vec{b} [1 - e^{-n(b,s)}]$$

AVERAGE NUMBER OF COLLISIONS AT GIVEN ENERGY AND IMPACT PARAMETER

- $n(b, s) = n_{soft}(b, s) + n_{hard}(b, s)$

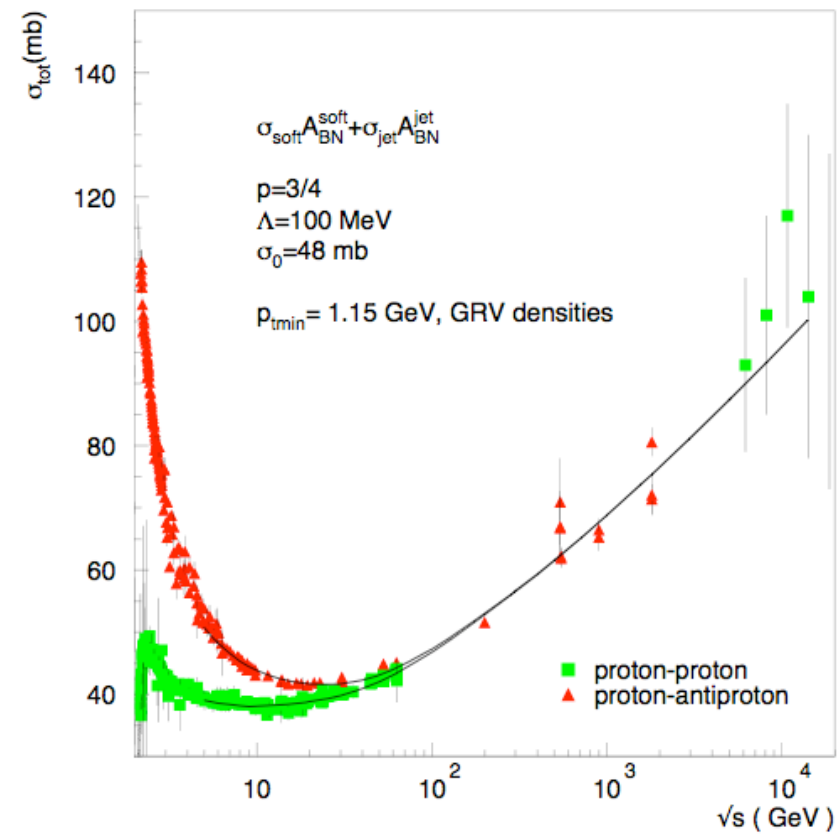
- $n_{soft/hard}(b, s) = A_{BN}^{soft/hard}(b, s) \sigma_{soft/hard}(s)$


b and s need not be factorized

MODEL FOR HARD AND SOFT INTERACTIONS

- Work with A. Achilli, A. Grau, R.M. Godbole, Y.N. Srivastava
- Eikonal mini-jet model with soft gluon resummation

A. GRAU,
R.M.
GODBOLE
AND Y.N.
SRIVASTAVA
PHYS. REV.
D 72,
076001
(2005)



8/8/07

THE QUESTIONS ARE :

- What makes the cross-section rise?
- What makes the cross-section rise within the limits imposed by the Froissart bound?

TWO MECHANISMS

- **Rise** is due to increasing number of gluons which undergo “hard” collisions, namely **PQCD** calculable interactions
- **Saturation** of Froissart bound is due to increasing **acollinearity** of “hard” partons because of initial state energy dependent soft gluon emission

OUR MODEL IS BASED ON

1. **eikonal** transformation which implies multiple scattering and requires **impact parameter distributions** inside scattering particles and basic scattering cross-sections
2. **hard** component of scattering responsible for the **rise** of the total cross-section
3. **soft gluon emission** from scattering particles which softens the rise and gives **b-distribution**

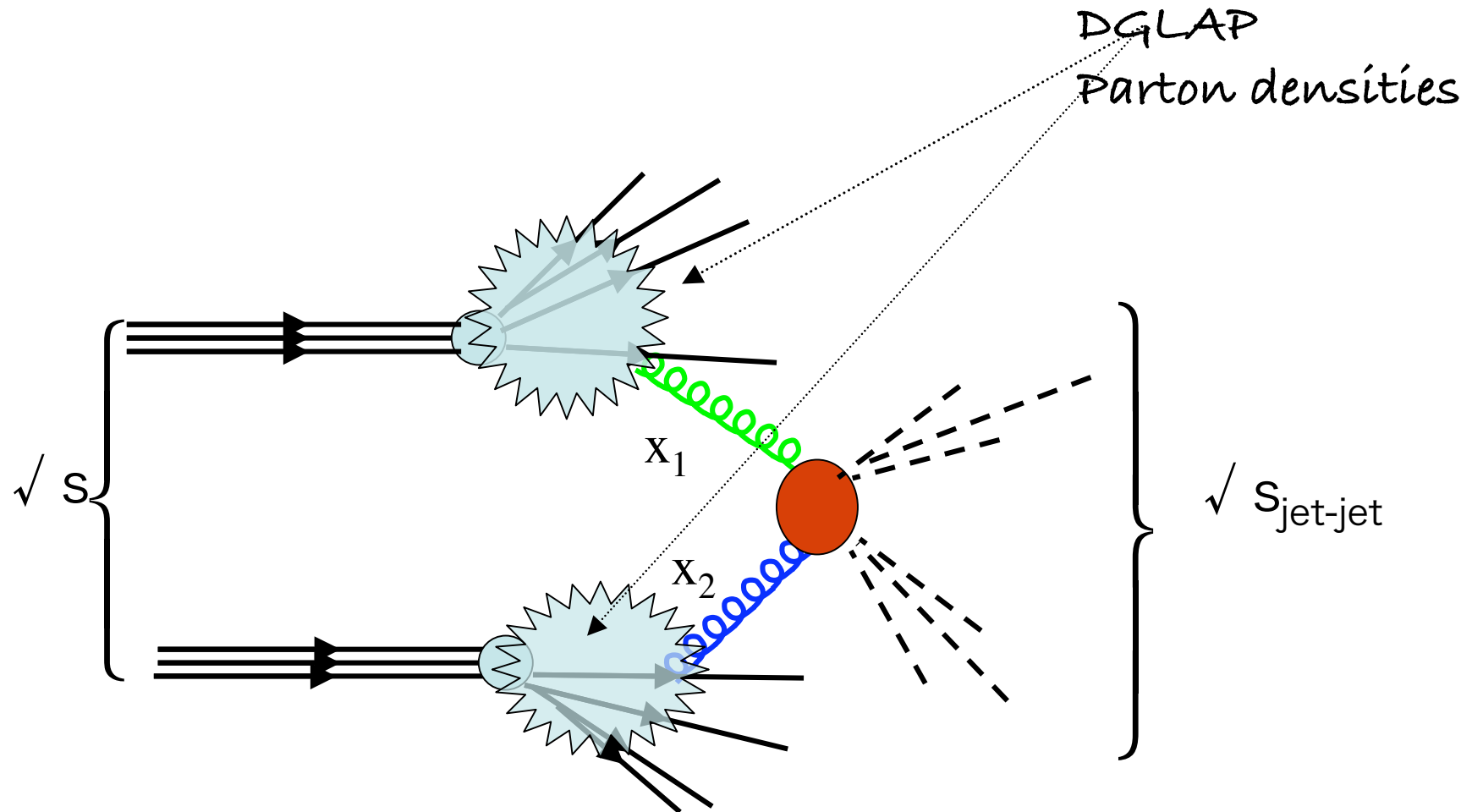
1. EIKONAL TRANSFORMATION

$$\sigma_{total} = 2 \int d^2\vec{b} [1 - e^{-\chi(b,s)}]$$

With $\Re\chi(b,s) \approx 0$ and $\Im\chi(b,s) = n(b,s)/2$

- $\sigma_{inel} = \int d^2\vec{b} [1 - e^{-n(b,s)}]$
- $\sigma_{total} = 2 \int d^2\vec{b} [1 - e^{-n(b,s)/2}]$

2. **Hard** component of scattering responsible
for the **rise** of the total cross-section



JET CROSS-SECTIONS AT LO

Using current
DGLAP evolved
PDF's :

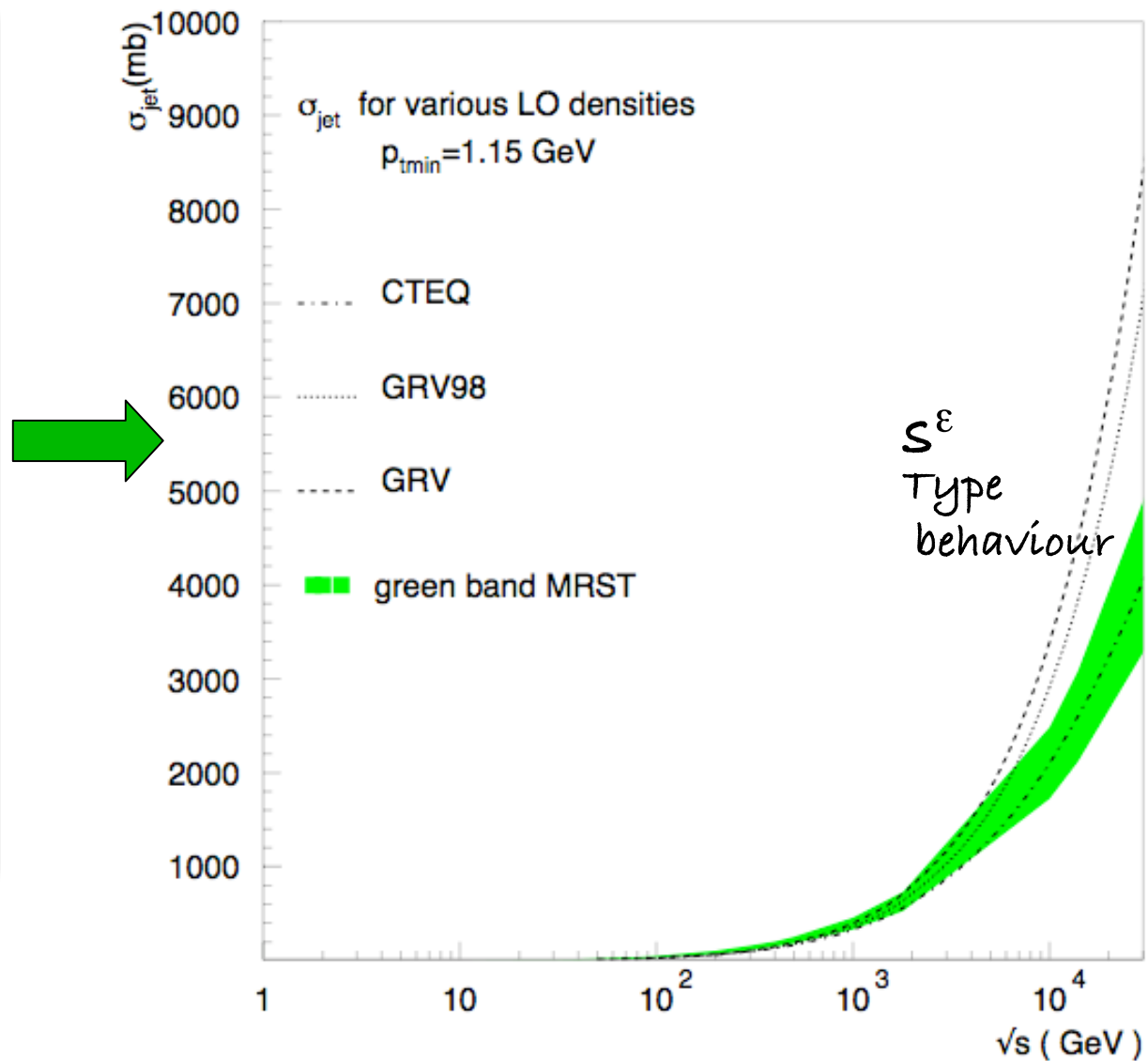
GRV, MRST, CTEQ

$$\sigma_{\text{jet}}^{AB}(s, p_{t\min}) =$$
$$\int_{p_{t\min}}^{\sqrt{s}/2} dp_t \int_{4p_t^2/s}^1 dx_1 \int_{4p_t^2/(x_1 s)}^1 dx_2 \times$$
$$\sum_{i,j,k,l} f_{i|A}(x_1) f_{j|B}(x_2) \frac{d\hat{\sigma}_{ij}^{kl}(\hat{s})}{dp_t}.$$

2.

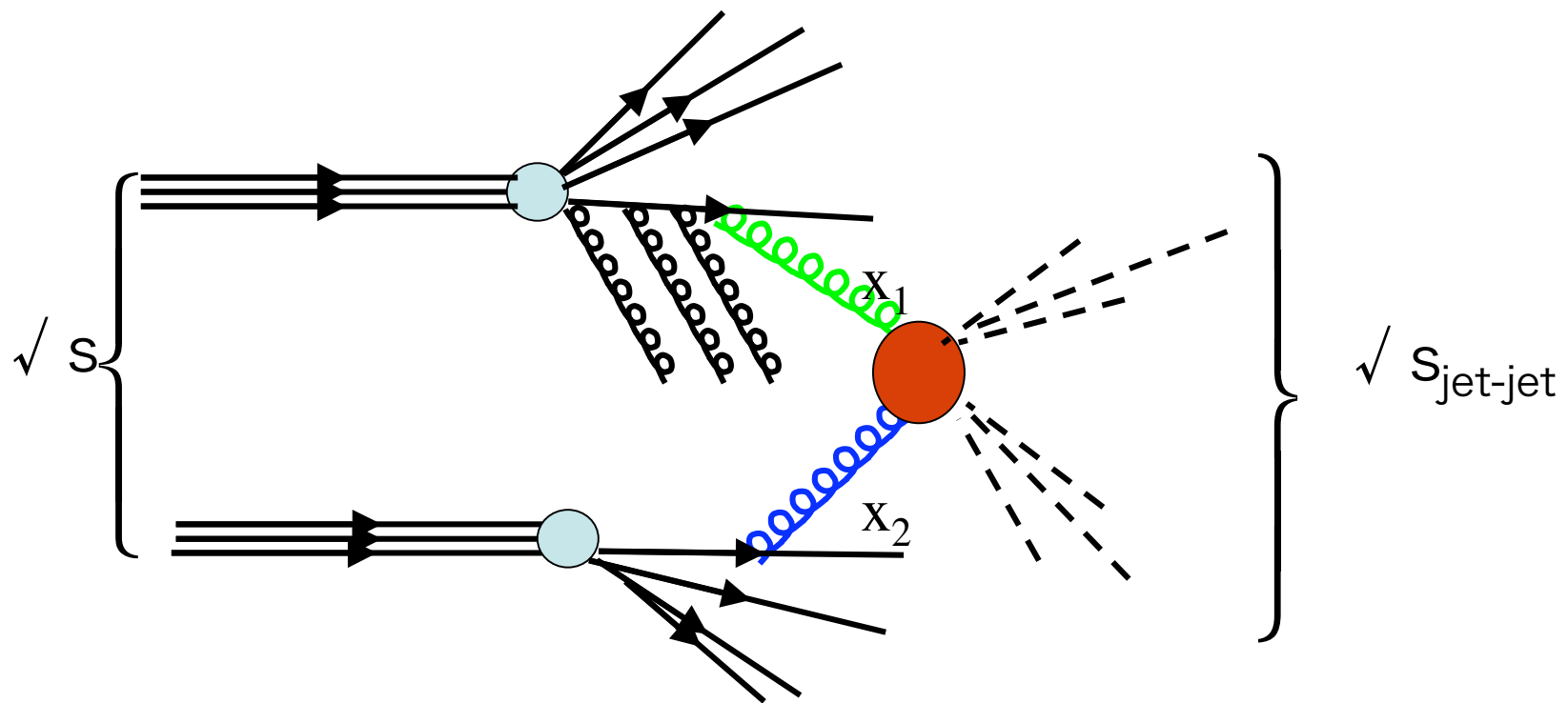
HARD
COMPONENT
OF
SCATTERING
RESPONSIBLE
FOR THE **RISE**
OF THE TOTAL
CROSS-
SECTION

$$\sigma_{hard} \equiv \sigma_{jet}^{AB}(s, p_{tmin})$$



8/8/07


3. **SOFT GLUON EMISSION** FROM SCATTERING PARTICLES WHICH SOFTENS THE RISE AND GIVES **B-DISTRIBUTION**



SOFTENING THE RISE

- **Soft** gluons change the parton collinearity
- Higher energy  more emission

more acollinearity


smaller x-section

SOFT GLUON EMISSION

According to our model, soft gluon emission down to zero momentum modes is responsible for the initial decrease in $p p$, as well as for the

transformation of the sharp rise due to the increase in gluon-gluon interactions

into a smooth behavior

3. SOFT GLUON EMISSION FROM SCATTERING PARTICLES WHICH SOFTENS THE RISE AND GIVES B-DISTRIBUTION

$$A_{BN}(b, s) = N \int d^2 K_{\perp} e^{-i K_{\perp} \cdot b} \frac{d^2 P(K_{\perp})}{d^2 K_{\perp}}$$

$$\frac{d^2 P(K_{\perp})}{d^2 K_{\perp}} = \frac{1}{(2\pi)^2} \int d^2 \vec{b} e^{i K_{\perp} \cdot b - h(b, q_{max})}$$

$$h(\vec{b}, q_{max}) = \int_0^{q_{max}} d^3 \vec{n}(k) [1 - e^{-i k_t \cdot b}]$$

$$\approx \int_0^{q_{max}} \frac{\alpha_s(k_t^2)}{8\pi} \frac{dk_t}{k_t} \log \frac{2q_{max}}{k_t} [1 - e^{-i k_t \cdot b}]$$



Soft gluon emission factor

WHAT ONE NEEDS TO CALCULATE $A(B,s)$

- Limits of integration
for soft gluon factor $\int dn_g(k)[1-e^{ikb}]$
- upper limit $q_{\max}^{(s)}$
- lower limit $k=0$ but then need to model
 $\int dk \alpha_s(k)$ down into the infrared region

OUR MODEL IN THE INFRARED

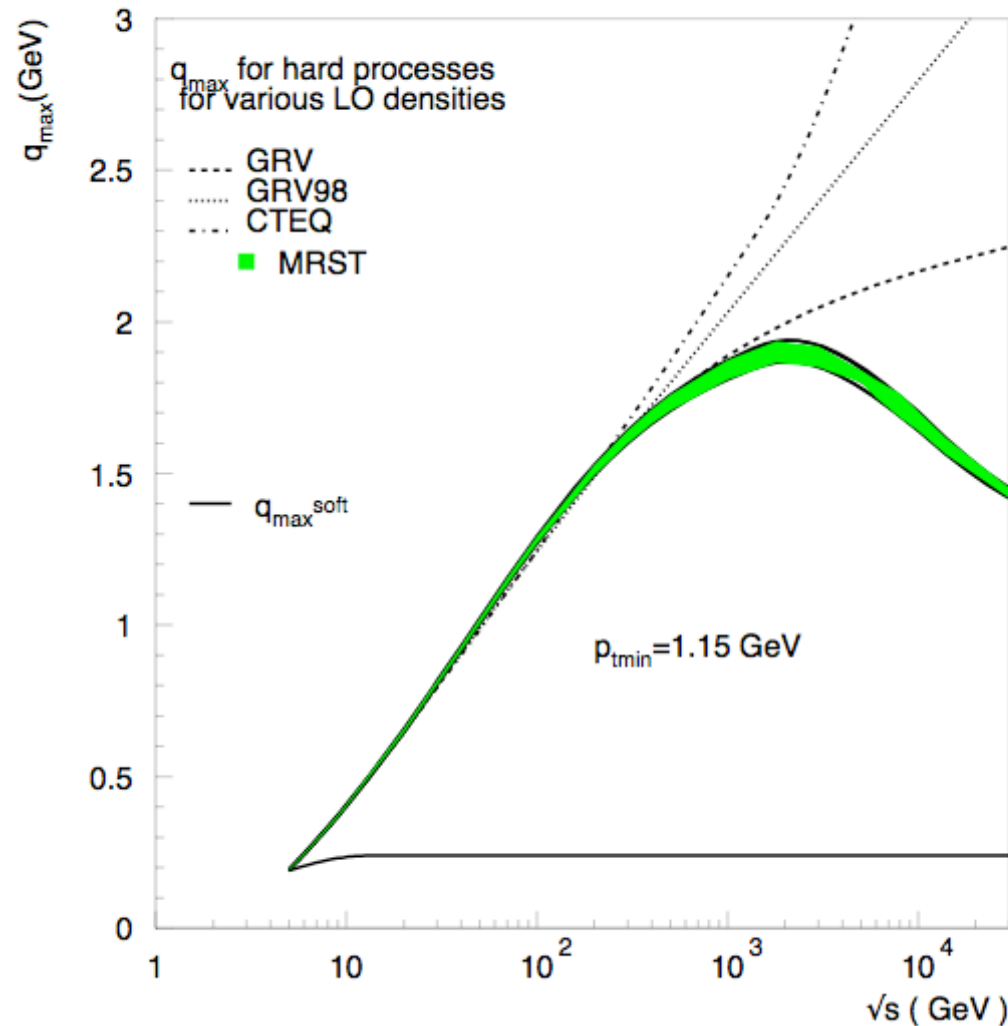
- Singular but integrable

$$\alpha_s(k_t^2) = \frac{12\pi}{33 - 2N_f} \frac{p}{\log[1 + p(\frac{k_t^2}{\Lambda^2})^p]}$$

- Singularity regulated by $p < 1$

$$q_{max}(s) = \frac{\sqrt{s}}{2} \frac{\sum_{i,j} \int \frac{dx_1}{x_1} f_{i|A}(x_1) \int \frac{dx_2}{x_2} f_{j|B}(x_2) \sqrt{x_1 x_2} \int_{z_{min}}^1 dz (1-z)}{\sum_{i,j} \int \frac{dx_1}{x_1} f_{i|A}(x_1) \int \frac{dx_2}{x_2} f_{j|B}(x_2) \int_{z_{min}}^1 (dz)}$$

soft
gluon
scale



Average
over same
PDF as
for σ_{jet}

HOW ABOUT N_{SOFT} ?

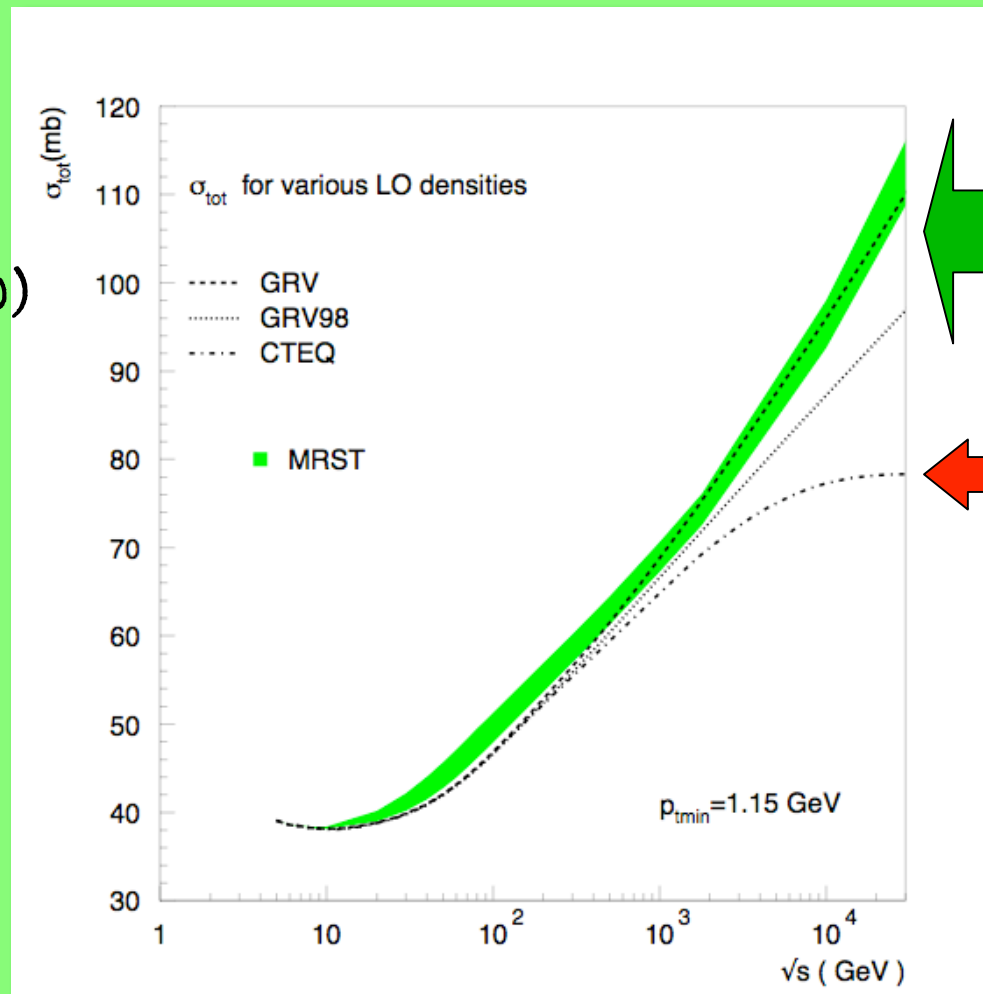
$$n_{\text{soft}}(b, s) = A_{BN}^{\text{soft}}(b, s) \sigma_0 (1 + \epsilon \frac{2}{\sqrt{s}})$$

$\epsilon = 0, 1$ depending upon the process being pp or $p\bar{p}$

- Parametrized with a constant σ_0
- With $p_{t\min}$ dependence through $A(b, s)$

FOR $p_{TMIN}=1.15$ GEV AND A CHOSEN SET
OF LOW ENERGY PARAMETERS

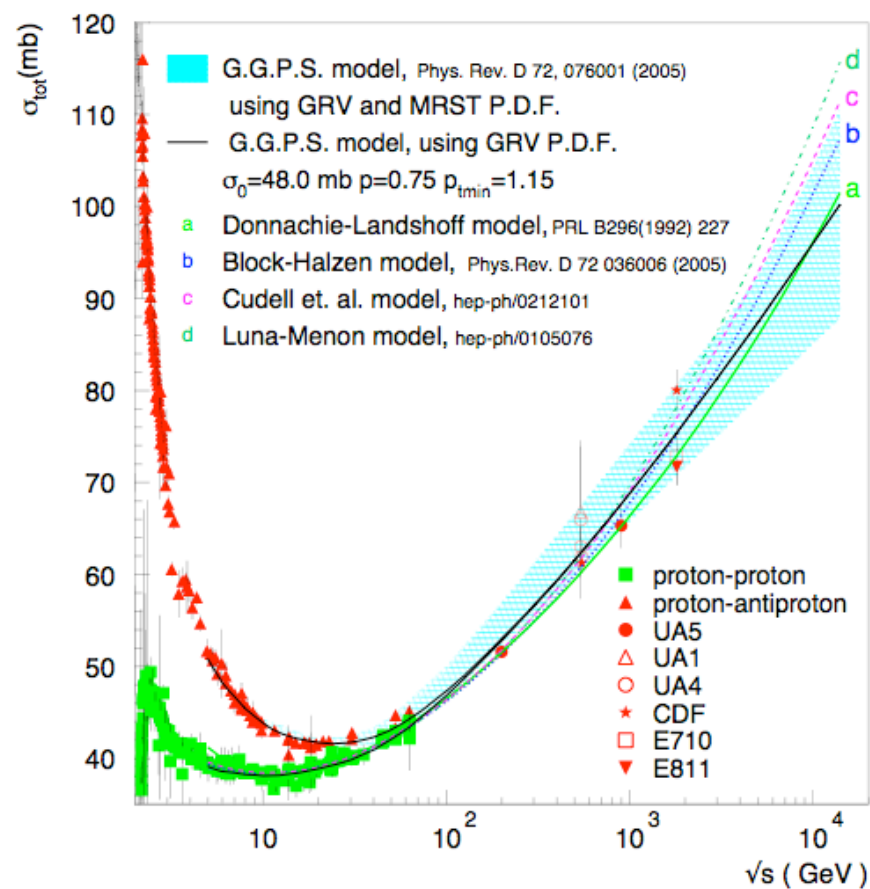
σ_{tot} (mb)



acceptable

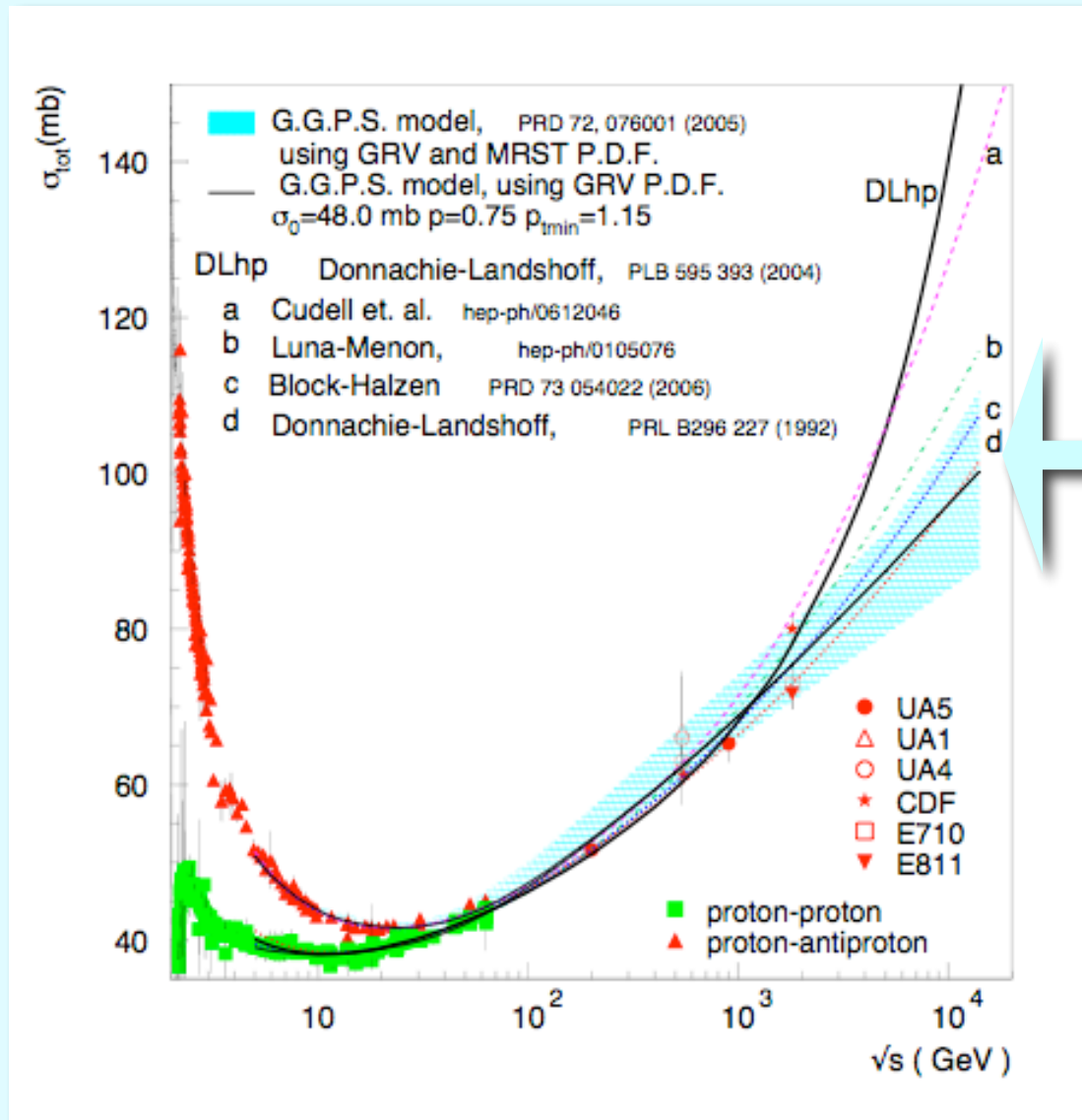
Not
good

Comparing with data and other models



GRV
MSRST

WITH HARD POMERON MODELS



SURVIVAL PROBABILITY

Probability of **not** having an inelastic collision

$$P_{no-inel} = e^{-n(b,s)}$$

Can be used to calculate the survival probability of Large Rapidity Gaps for collisions at given b-value in a colorless exchange

SURVIVAL PROBABILITY

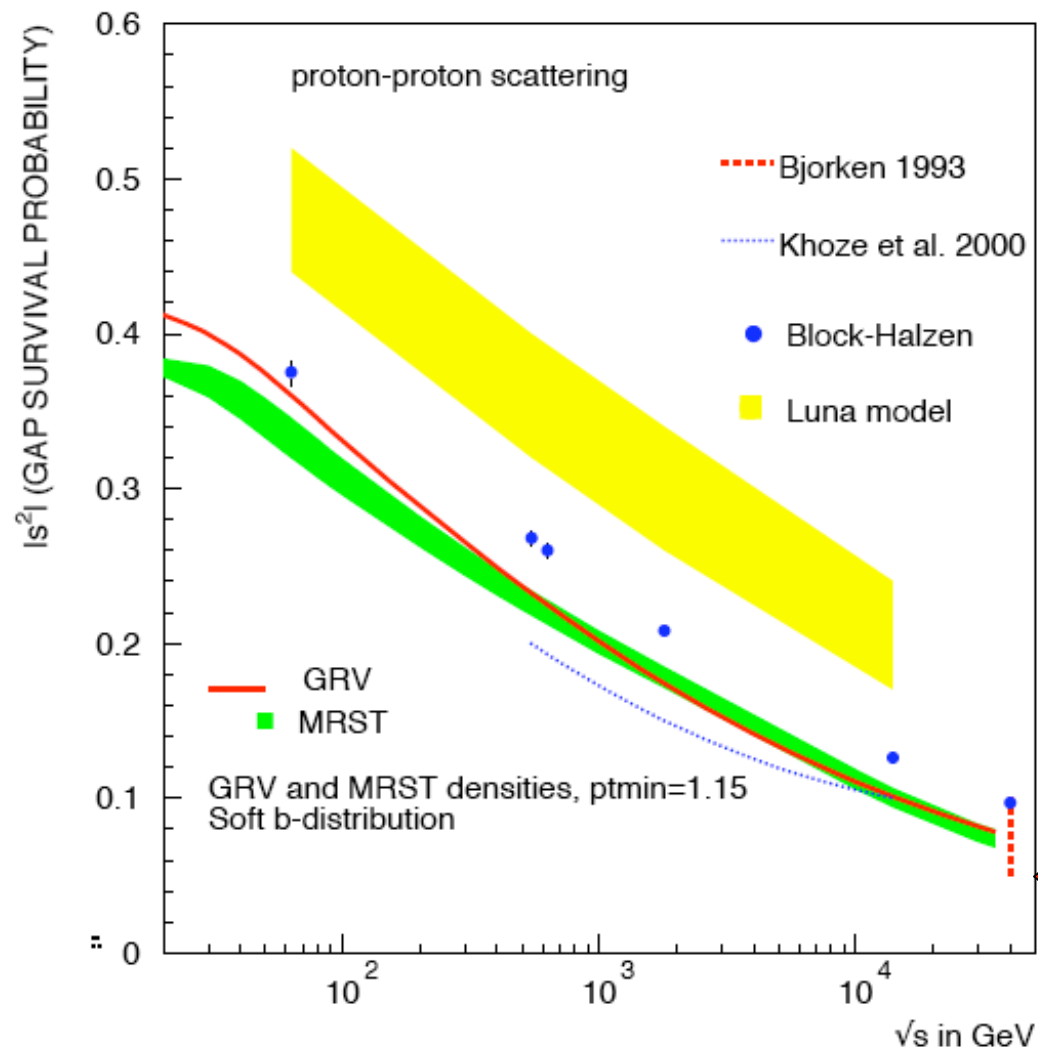
$$\langle |S|^2 \rangle = \int d^2\vec{b} A(\vec{b}, q_{max}^{soft}) |S(\vec{b})|^2$$

we use the soft b-distribution $A(\vec{b}, q_{max}^{soft})$

$$\int d^2\vec{b} A(\vec{b}, q_{max}^{soft}) = 1$$

$$|S(\vec{b})|^2 = P_{no-inel}$$

COMPARING WITH OTHER MODELS



Bjorken

CONCLUSIONS

- We have built a model for the total cross-section which
 - Incorporates **hard** and **soft gluon** effects
 - Satisfies the limits from the **Froissart** bound
 - Can be used to study other minimum bias effects like **Survival Probability of Large Rapidity Gaps**
 - Easily extended to γp and $\gamma\gamma$

1. EIKONAL
TRANSFORMATION
IMPLIES MULTIPLE
SCATTERING

